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# Art. XIV.—*Note on the Real Significance of the Michelson-Morley Experiment.*

By E. F. J. LOVE, M.A., D.Sc.

(University of Melbourne).

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In the year 1887, Michelson and Morley[1] published their well-known research having for its object the detection and measurement of the speed and direction of the earth's motion relative to the ether of space. The apparatus employed by them at the time was fully adequate to their purpose; as subsequently modified by Michelson,[2] it became capable of affording measurements of considerable precision; yet the result was uniformly null.

The obvious conclusion to draw was that the relative speed was zero; i.e., that the ether in the neighbourhood[3] of the earth is carried along with it in its orbital motion. The difficulty of such a conclusion lay in the fact that all other investigations, carried out up to that—or even the present—date, go to prove that the relative speed in question and the earth's orbital velocity are indistinguishable; in other words, that the earth's motion leaves the ether undisturbed.[4]

In 1892, Fitzgerald[5] and Lorentz[6] independently suggested their (now famous) "contraction hypothesis" as a way out of the difficulty. This asserts that a material body, when set in motion, undergoes a change of linear dimension in the direction of that motion. As the phenomena of electrolysis had already proved the mutual actions of atoms in the molecule to be, in part at least, electrical, the occurrence of *some* such change could hardly be disputed; it only needed recognition; but its sign and amount were alike undetermined by such phenomena as those of electrolysis. Fitzgerald and Lorentz accordingly suggested that the change might, for all that was known at the time, very well be a contraction, of the right amount to account for Michelson and

1 Phil. Mag. [v.], xxiv., 1887, p. 449.

2 Am. Journ. Sci. [iv.], iii., 1897, p. 475. Many later writers seem to have overlooked this interesting paper.

3 The term "neighbourhood," as the paper quoted in note 2 shows, must be liberally interpreted.

4 Which is not quite the same thing as saying that the ether is at rest in space.

5 Nature, xlvi., 1892, p. 165.

6 Versl. d. k. akad. van Wet., 1892-3, p. 74.

Morley's negative result. Their discussion really proved that the Michelson-Morley experiment was not conclusive as to the relative motion in question; Michelson apparently accepted this point of view, as in his paper of 1897,[1] he specifies the hypotheses:—

(a) Independence of motion;

(b) The contraction hypothesis;

(c) Influence of the earth on the ether at the distance apparently required by his experiments,

as all about equally difficult to credit.

During the next ten years, Larmor and Lorentz, working independently, developed the mathematical consequences of a new electrodynamic theory, in which the atoms of matter were regarded as complexes of positive and negative electrons, capable of free motion, in a medium which that motion left undisturbed. Larmor[2] was the first to succeed in extending the computations of this theory to the second order of small quantities, and so to conclude—

(a) That the contraction posited by Fitzgerald and Lorentz would necessarily take place in matter constructed from such atoms.

(b) That its magnitude would be independent of the chemical nature of the moving matter.

(c) That this magnitude would be numerically equal to half the square of the astronomical Constant of Aberration; i.e., precisely that required to account for Michelson and Morley's results.

(d) That these results would consequently come into line with the positive results of other experiments as evidence for the equality, within the limits of experimental error, of the earth's orbital velocity with the relative velocity of the earth and the ether.

Larmor's result was often misunderstood at the time, as it was supposed—though quite erroneously[3]—to be dependent on his special theory of electronic structure; but its pertinence was something more than confirmed when Lorentz[4] proved that the contraction was not a mere second approximation, but an exact result of their electrodynamic theory.

In all probability these investigations would have been regarded as conclusive, but for the reluctance, long felt by chemists and physicists alike, to accept a purely electrodynamic theory of

1 See note 2, *supra*.

2 Aether and Matter, pp. 173-176.

3 Larmor had actually anticipated (l.c., p. 86) and warned his readers against this misinterpretation of his general argument.

4 Proc. Amst. Acad. (English edition), vi., p. 809.

inertia. It was possibly owing to this reluctance that the experiments of Morley and Miller[1] which proved the null result of the Michelson-Morley experiment to be independent of the material of which the apparatus was constructed, were regarded more as a cause for wonder than as—what they really were—a brilliant conformation of Larmor's predictions

Times have changed. Owing to researches such as those in which Thomson, the Curie's and Rutherford were pioneers—researches far removed from the domain of experimental optics—the electron theory of atomic constitution may be regarded as firmly established, quite as much so as the atomic theory itself. This being the case, we are entitled to assume it as the basis of argument, instead of its conclusion. Under these conditions, the occurrence of the Fitzgerald-Lorentz contraction is no longer a hypothesis, but an immediate deduction from our theory of matter. The Michelson-Morley experiment, combined with this deduction, then takes its rightful place among the evidences for the relative independence of material and etherial motion—a place of pre-eminence, as it is the only experiment on the subject yet designed, much less completed, in which quantities of the second order of smallness are involved in measurable fashion. This, then, we take to be its real significance; it is a valuable piece of evidence, perhaps the most valuable we have, in favour of the very theory which it was at first supposed to have disproved.

If this idea be correct, it is important to notice that it holds good independently of all questions as to the relation between the Lorentzian electrodynamics and modern relativity doctrines. Whether the Principle of Relativity be the expression of a profound physical truth or a brilliant mathematical speculation, the significance of Michelson and Morley's result, as a demonstration of the independence of the motion of the earth and ether, remains the same.

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1 Phil. Mag. [vi.], ix., 1905, p. 680.